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NAVAL RECORD COMMUNICATIONS:
DEMAND REDUCTION FOR
THE NAVAL TELECOMMUNICATIONS SYSTEM

by

Kathleen A. McClurg

June, 1991

Thesis Advisor: William Gates

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This thesis analyzes the economic causes for continued excess demand in the Naval Telecommunications System (NTS). It provides a framework for relating the NTS market to the market for all Naval record communications. Substitute systems for specific types of Naval messages are identified along with reasons why these systems are not used. In some cases, fascimile (FAX) or personal computer (PC) networking can substitute for the NTS. Unfortunately, most users do not have access to these systems and/or would have to use their budget to gain access and to use these systems. Using microeconomic analysis, several alternative policies to reduce excess NTS demand are discussed in this thesis. Alternatives explored include; charging prices for NTS use, introducing inefficiencies to the NTS, subsidizing all Naval record communications, and administratively denying NTS use by precedence, communicty, and/or time period. For various reasons, pricing, introducing inefficiencies, and subsidizing record communications are not considered viable solutions. Administrative denial methods may be a more viable way to reduce demand for the NTS during peak periods.

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Naval Record Communications:
Demand Reduction for
The Naval Telecommunications System

by

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Lieutenant, United States Navy
B.S.I.M., Purdue University

Submitted in partial fulfillment
of the requirements for the degree of

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ABSTRACT

This thesis analyzes the economic causes for continued excess demand in the Naval Telecommunications System (NTS). It provides a framework for relating the NTS market to the market for all Naval record communications. Substitute systems for specific types of Naval messages are identified along with reasons why these systems are not used. In some cases, facsimile (FAX) or personal computer (PC) networking can substitute for the NTS. Unfortunately, most users do not have access to these systems and/or would have to use their budget to gain access to and use these systems. Using microeconomic analysis, several alternative policies to reduce excess NTS demand are discussed in this thesis. Alternatives explored include; charging prices for NTS use, introducing inefficiencies to the NTS, subsidizing all Naval record communications, and administratively denying NTS use by precedence, community, and/or time period. For various reasons, pricing, introducing inefficiencies, and subsidizing record communications are not considered viable solutions. Administrative denial methods may be a more viable way to reduce demand for the NTS during peak periods.

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I. INTRODUCTION

A. BACKGROUND

The Naval Telecommunications System (NTS) frequently experiences excess demand and is unable to meet speed of service (SOS) objectives requested by users. To alleviate this problem managers of the NTS must either increase system capacity, reduce demand, and/or formulate a combination of these alternatives. Previous theses have reviewed demand management methods, attempted to define pricing schemes, and researched a combination of ideal capacity and demand management. (DiMaggio, 1989) (DeLeeuw, 1990)

B. OBJECTIVES

The purpose of this thesis is to compare the market for the NTS with other sources of record communications in the Navy and suggest demand management methods to improve the efficiency of overall record communication usage. Demand management methods which would improve efficiency, as viewed through SOS objectives, are sought by using microeconomic theory to clearly define the market for the NTS and forms of record communications which may be used as substitutes for Naval message traffic. Specific questions addressed are:

- What microeconomic principles will explain the excess demand for the NTS?

- How do microeconomic principles relate to the NTS?
- What is the market for record communications in the Navy?
- How can other available record communications systems be used to improve the NTS efficiency?
- What alternative methods may induce NTS users to reduce demand on the system?

C. SCOPE AND LIMITATIONS

This thesis analyzes the market for record communications in the Navy and reviews possible demand management methods which will reduce the demand for NTS services. Speed of service (SOS) objectives are used as a measure of efficiency. The benefits and limitations of record communications systems which may substitute for Naval messages are explored. Basic microeconomic theory is used as the primary analytic tool. Drawing on the author's experiences, this theory is applied to the market for record communications. This thesis will help expand the viewpoint of record communications users and offer options to record communications managers for future policy to reduce demand on the NTS.

This thesis does not perform a cost analysis nor complete network analysis of record communications systems available. Specific numerical analysis would entail a vast amount of cost and network data which is beyond the scope of this thesis.

D. ORGANIZATION OF STUDY

Basic microeconomic theory is introduced in chapter II followed by an analysis of the Naval Telecommunication System in chapter III. Chapter IV discusses the entire market for record communications in the Navy and suggests substitutes for specific types of Naval messages. Options for reducing NTS demand are presented in chapter V, followed by conclusions and recommendations for further study in chapter VI.

II. BASIC MICROECONOMIC THEORY

A. INTRODUCTION

Every day, the United States Navy Sends large quantities of paper message traffic through the Naval Telecommunications System (NTS). The NTS supports "hard copy" or record message traffic around the world through a varity of transmission media, ranging from satellite communications to leased fiber optic lines. The capacity of the NTS is commonly inadequate to ensure secure, rapid, and reliable transmission of information. The primary concern of this thesis is the timeliness or rapidity that information arrives to the fleet. The lack of adequate capacity to support the navy may be understood more clearly through several basic economic concepts.

B. DEMAND

Demand centers around the relationship between the quantity of a good or service that will be purchased and the given price provided all other determinents remain constant. Factors which may be held constant include the price of substitutes or complements, the quality of the product, and the income of the consumer. Holding these determinents constant is referred to as *ceteris parabis*. Under the conditions of *ceteris parabis*, a demand schedule may be

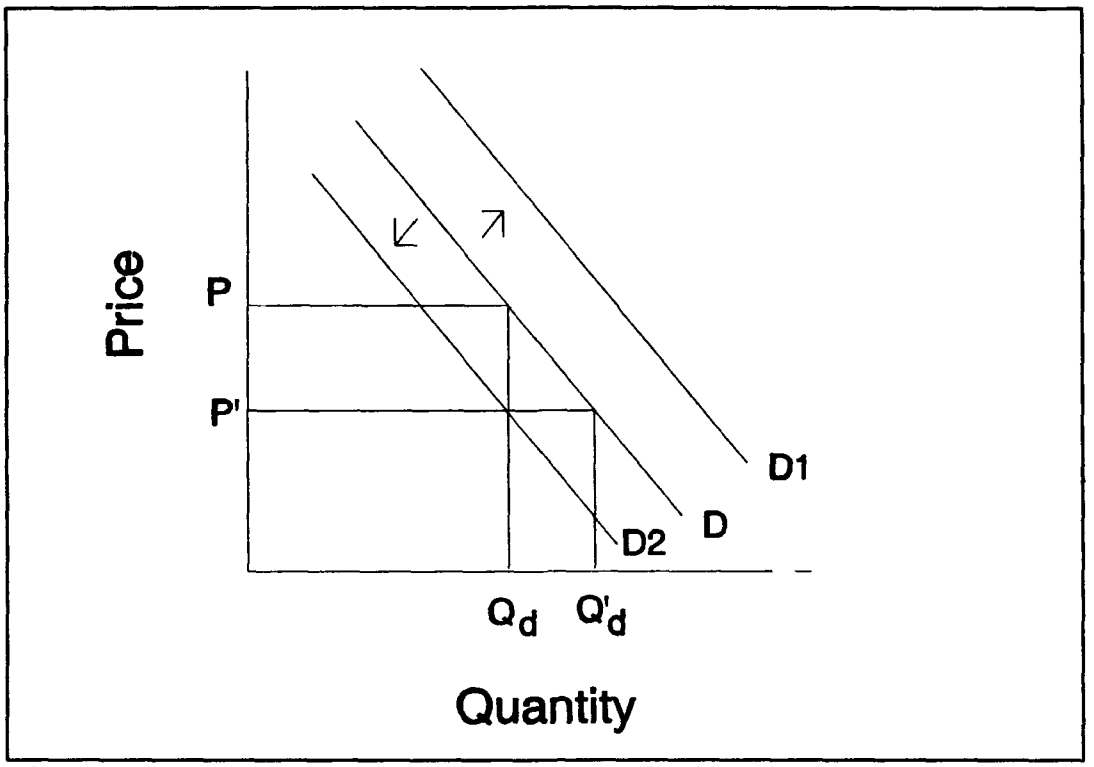

Figure 1. Demand Function

graphed. The price of the good or service is on the vertical axis while the quantity of the product is on the horizontal axis. The line labeled D in figure 1 reflects a typical demand curve.

Several relationships between the quantity demanded and varying prices can be inferred from the demand curve (D). The demand curve is downward sloping which indicates that the normal consumer will buy less of a good or service as the price increases. There are two types of changes that take place relative to the demand curve: movements along the demand curve and shifts in the demand curve. Changing the price (P) of a good causes a movement along the demand curve.

In contrast, changing any other factors determining a consumer's demand for a good violates ceteris parabis and causes a shift in the demand curve, depicted as **D1** or **D2** in figure one.

If the price of the good or service changes there is movement along the demand curve. As the price shifts from **P** to **P'**, the quantity demanded moves from Q_d to Q_d'. The fact that consumers are willing and able to buy more of a good if the price is lower is called the law of demand.

If any determinent other than price is changed, the demand curve shifts to display a new relationship between price and quantity demanded. This shift, shown as **D1** or **D2**, may be in either direction, reflecting either a greater **(D1)** or smaller **(D2)** quantity demanded at the same price.

1. **Marginal Value**

Marginal analysis is the method of determining the advantage or disadvantage caused by acquiring one more unit of a good. The demand curve reflects consumer's marginal value. The demand curve shows how much consumers are willing to pay for each additional unit of output. Thus, the demand curve shows the marginal value consumers receive from each additional unit. The consumer is willing to pay more for the

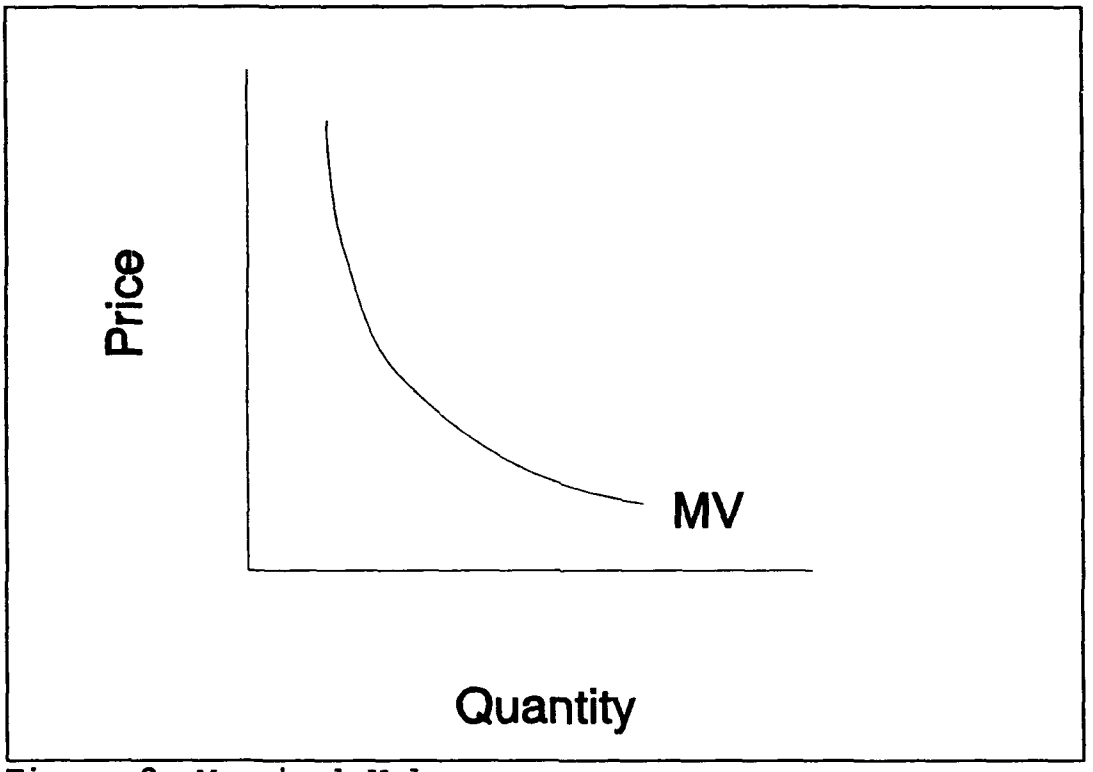

Figure 2. Marginal Value

first unit of a good than he is for second unit. Similarly, he is willing to pay less for each additional unit, as implied buy the downward sloping demand curve. This relationship is shown as a downward sloping marginal value curve in figure 2.

C. SUPPLY

The concept of supply reflects the relationship between price and the quantity of a good producers are willing to supply at that price. The concept of *ceteris parabis* continues to hold in that all determinents other than price are held constant. The determinents for the suply curve may include the technology available to produce the good and the

price of the raw materials. Supply may also be depicted on a graph, as shown by the line labeled **S** in figure 3. The supply curve tends to be upward sloping.

Movements on the supply curve are similar to those on the demand curve. When the price of the good changes from **P** to **P'**, the quantity supplied will move along the supply curve from Q_s to Q_s'. The higher the price the more manufacturers are willing to supply. Conversely, if one of the other determinents of supply changes, the supply curve will shift to the right or left (ie. from **S** to **S1** or **S2**), depending on the change.

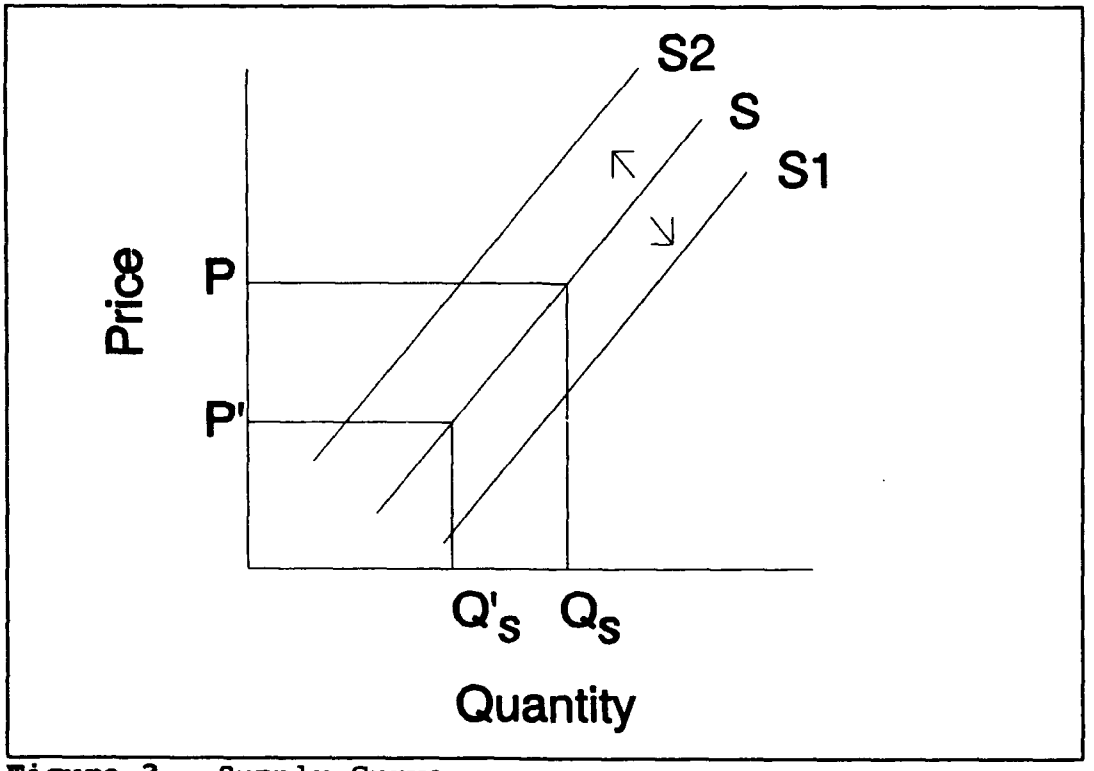

Figure 3. Supply Curve

There is no essential difference between supply and demand. Three basic assumptions are applied to two separate groups of people, consumers for the demand curve and manufacturers for the supply curve. The assumptions are: 1) Decision makers are given alternatives and choose among them; 2) Choices reflect a comparison of benefits anticipated from alternatives; and 3) The logic of economizing is the same for consumers and manufacturors.(Heyne, 1990, p. 52)

1. Marginal Cost

Marginal analysis can also be performed on the supply curve. In this case, the supply curve reflects the marginal cost associated with producing one more unit of a good. The marginal cost of producing each unit tends to increase as units are added to production. Figure 4 shows the marginal cost curve.

D. PRICE AND MARKET EQUILIBRUIM

The common attribute that supply and demand share is price. Economists think of price in terms of opportunity cost. Opportunity cost is the sacrifice made to consume or produce a specific quantity of a good. It reflects the cost of everything sacrificed as measured by the value of the next best alternative use of the resources. Consumers make their decisions to purchase by including such "non-monetary" considerations as the time they spend in acquiring a good.

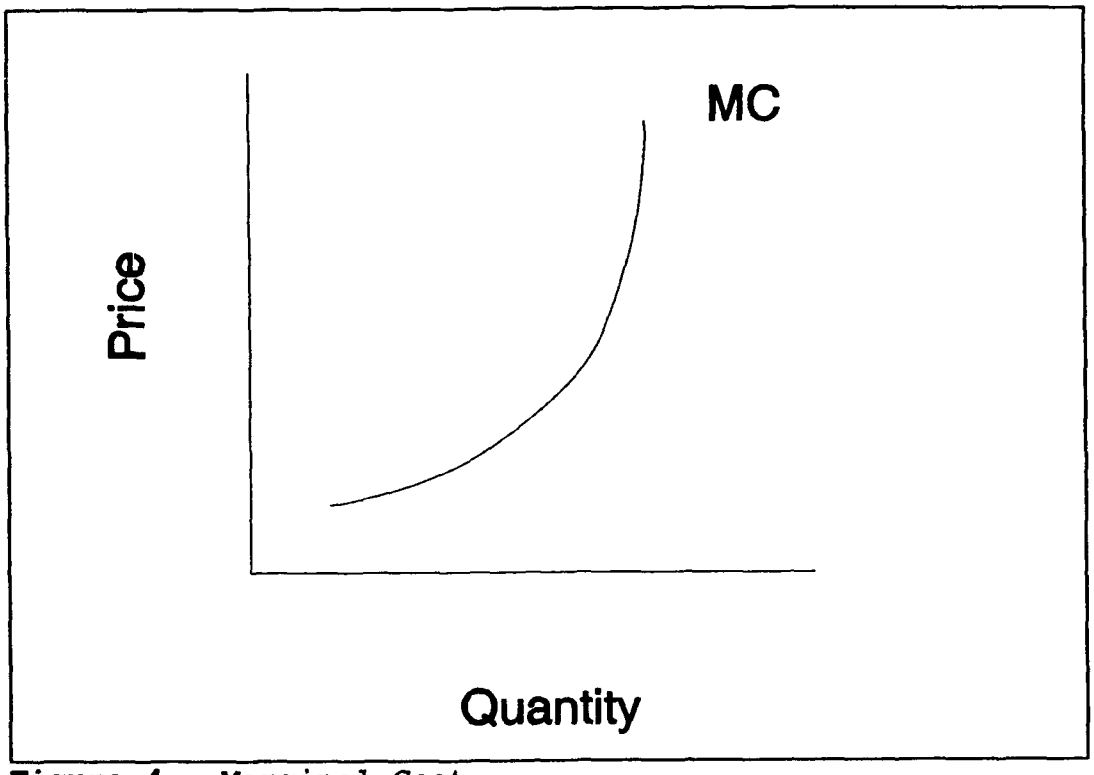

Figure 4. Marginal Cost

Manufacturers' prices will rise to the level that equates the profits they could expect to make if they used their resources to manufacture a product which will bring them the second highest return (ie the return just below the return they are getting for their present product). The demand and supply curves are only accurate to the extent that they reflect the entire opportunity cost to the consumers and producers, respectively.

While consumers and producers actively seek the most advantageous opportunity cost or price for themselves, they are actually joining forces to produce the market price. The market price is the price at which a good or service will be

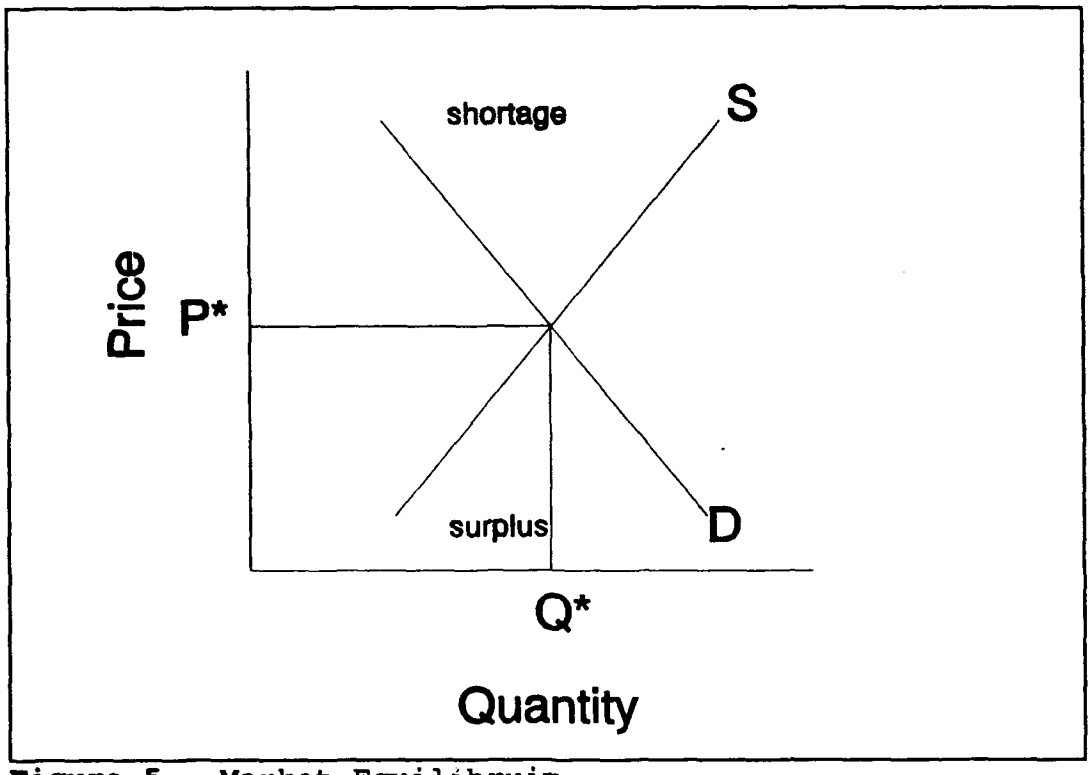

Figure 5. Market Equilibruim

purchased under conditions of perfect competition. Perfect competition assumes that the market produces equivalent or homogeneous products, that there are many producers of a good or service, and the producers are price takers (ie, producers cannot control the market price). The market price can be shown graphically by superimposing the demand curve and supply curve on the same set of axes, as shown in figure 5.

By graphing the supply and demand curve in this way, market equilibrium and market price are depicted. Market equilibruim is the position where quantity demanded equals quantity supplied, Q^*. After locating Q^*, read the market price, P^*, on the vertical axis. The market price will

support 100% of sales at the market equilibrium quantity. When the price is below the P^*, the quantity demanded, Q_d, will be greater than the quantity supplied, Q_s, producing a shortage of goods availble. When the price is raised above P^*, the quantity demanded will be less than the quantity supplied, producing a surplus of goods available.

When there is a violation of the *ceteris parabis* conditions for either demand or supply, there is a shift in the curves. As a result, market equilibrium and market price will be changed, depending on the direction of the shift.

1. Marginal Analysis of Market Equilibrium

The equilibrium point for the market can also be found by depicting marginal value and marginal cost on the same graph. The consumer will maximize their well-being by buying products at the point where marginal value equals marginal cost, **MV=MC**. This point is equivalent to the market equilibruim point.

If the consumer purchases one more unit, the **MV** will be less than the **MC** and the consumer would experience a net loss. Similarly, if the consumer buys one less unit of the good, the consumer's **MV** will be greater than **MC** and buying one more unit would cause a net increase in the consumer's well being. This is shown in figure 6.

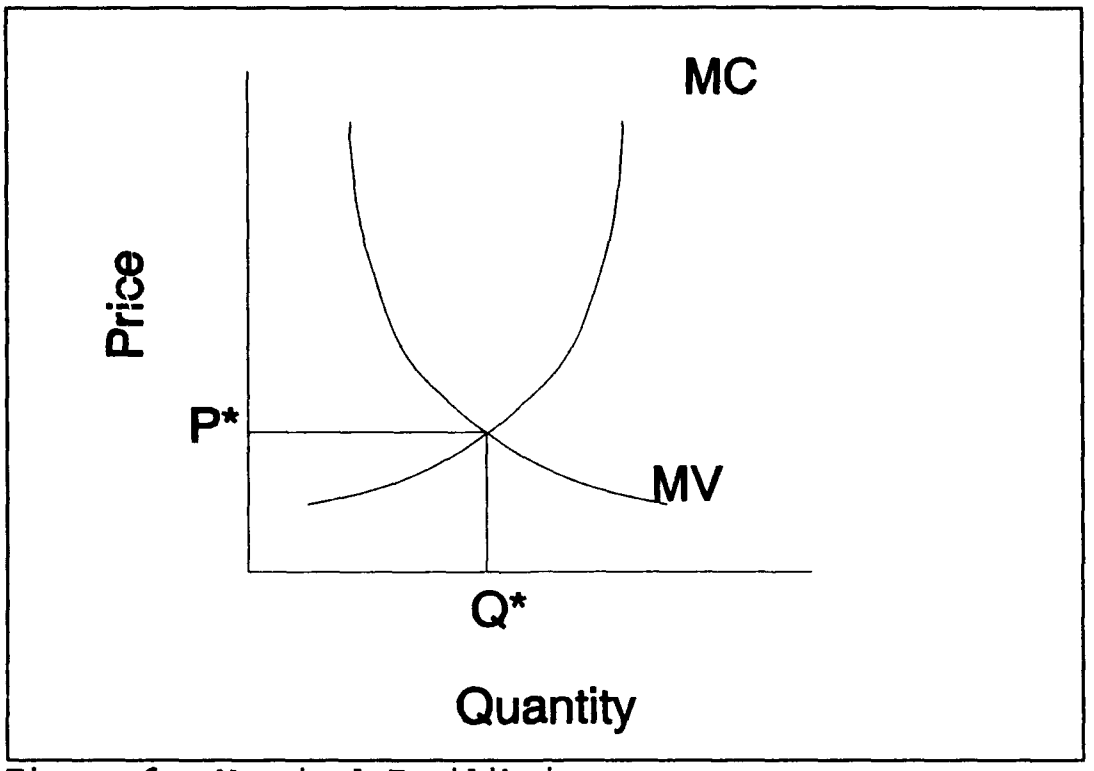

Figure 6. Marginal Equilibrium

E. EFFICIENCY

Efficiency requires deriving the maximum value for users and consumers. In a free market environment, efficiency is monitored by price. As a change in supply or demand occurs, the change in equilibrium price will cause a change in marginal value and/or marginal cost. Because consumers and producers wish to consume or produce where **MV=MC**, they will adjust their behavior to return to market equilibrium.

F. UTILITY

Utility is satisfaction consumers receive from the bundle of goods they consume. Consumers attempt to maximize their utility in deciding how to spend their money. While utility

can not be measured, it can be maximized by comparing the relationship of a consumer's value of one bundle of goods relative to their value of another bundle of goods. This relationship does not require a consumer to define an exact amount to each bundle of goods, but consumers are able to say whether the value of one bundle is higher (or lower) than the value of another bundle. Full understanding of utility requires both budget constraints and indifference curves.

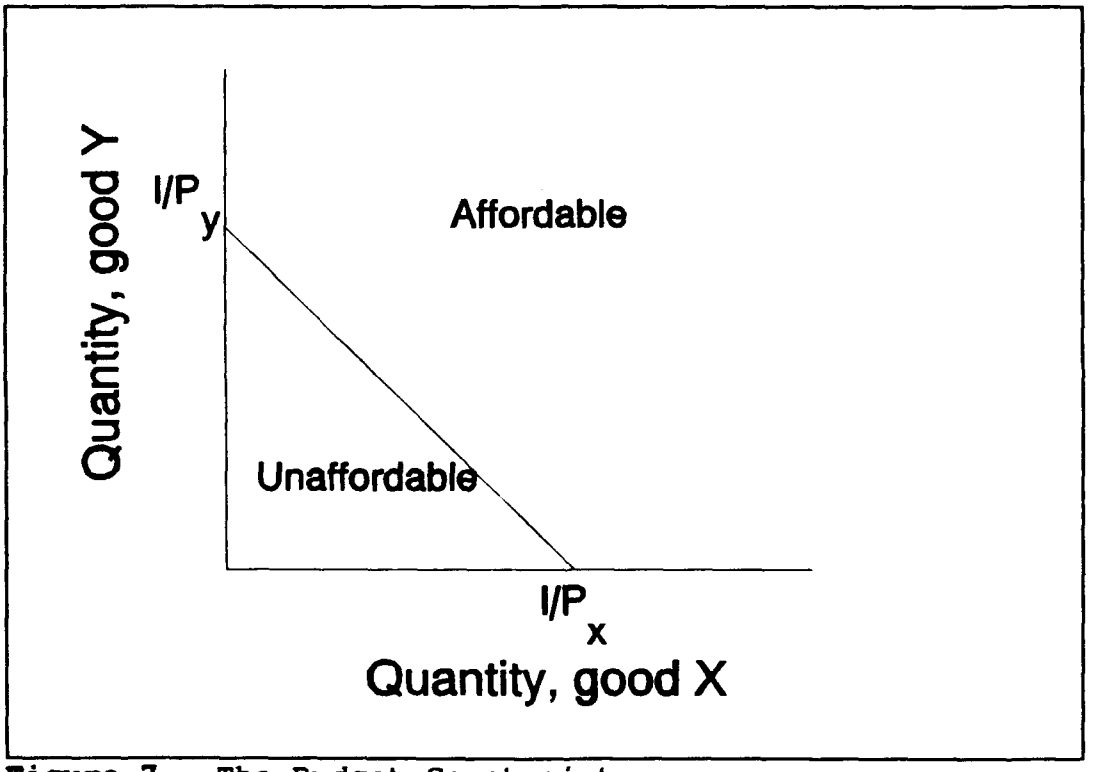

Figure 7. The Budget Constraint

1. Budget Constraints

The budget constraint or opportunity set is the amount of goods a consumer can afford to buy. Assume there are only two goods available to consumers, **X** and **Y**. A consumer will be able to buy various combinations of these goods based on the quantity of their income, **I**, and the price of each good. If the consumer decides to buy only product **X** and none of product **Y**, then the amount of **X** bought will be **I** divided by the price of **X**, P_X. Similarly, if the consumer only buys product **Y**, the amount of **Y** bought will be I/P_Y. Joining these two points on a graph by a straight line shows all combinations of **X** and **Y** the consumer can afford to purchase. This line is called the budget constraint and is depicted in figure 7. Any point on or below the budget constraint can be purchased with income **I**, and any point above the budget constraint is unaffordable to the consumer given price and income.

2. Indifference Curves

Indifference curves help define the consumer's individual preferences. These preferences can be ranked through three possible statements. The consumer prefers bundle **A** to bundle **B**, the consumer prefers bundle **B** to bundle **A** or the consumer has no preference for bundle **A** or **B**. In describing consumer's preferences, three assumptions are made: all possible bundles may be ranked; the consumer will prefer more of one good to less, all else being equal; and if the

consumer prefers bundle **A** to bundle **B** and bundle **B** to bundle **C**, then he will prefer bundle **A** to bundle **C**. These assumptions allow indifference curves, showing the combinations of X and Y between which the consumer is indifferent, to be formed and graphed.

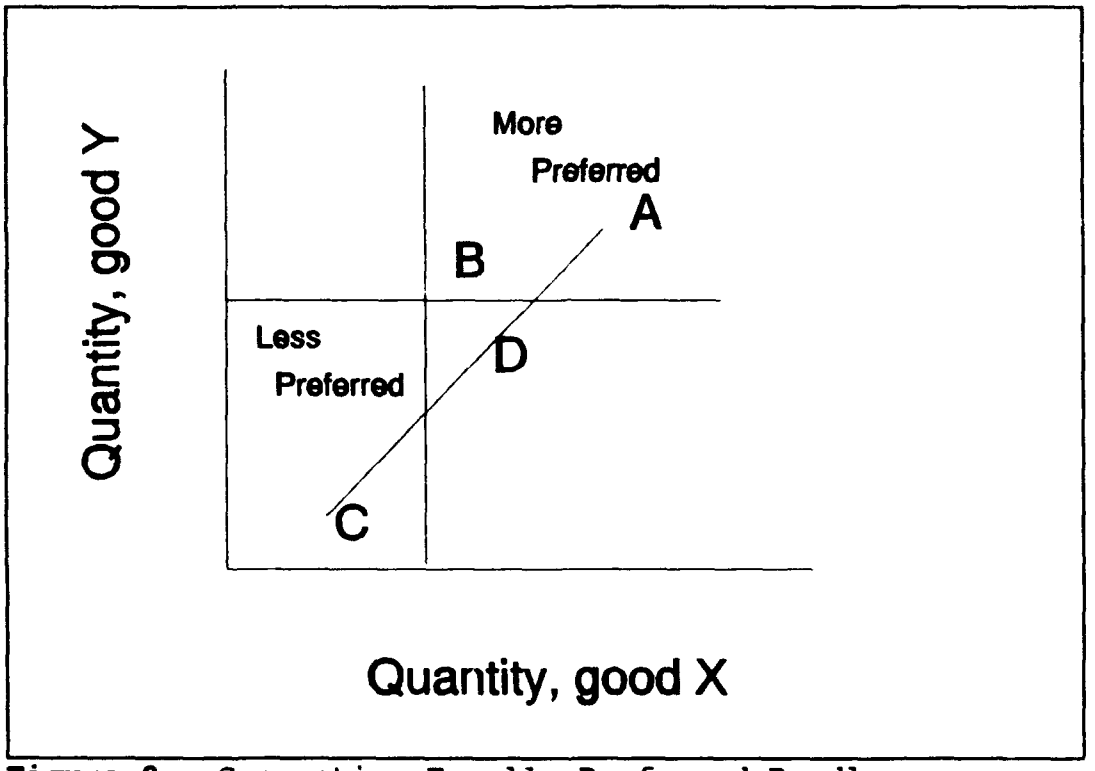

Figure 8. Generating Equally Preferred Bundles

Indifference curves are generated by first plotting bundle **B** of goods **X** and **Y**, as shown in figure 8. Any bundle of goods to the upper right of bundle **B** will be preferred over **B** because the consumer will get more of **Y** without sacrificing any **X**. Any goods to the lower left of **B** will be less preferred to **B** because the consumer will have less of **X** and **Y**. Bundle **A** is preferred to bundle **B** and bundle **B** is preferred to

bundle C. When a straight line is draw between points **A** and C, there must be a point along that line, **D**, which will be equally preferred to bundle **B**. (Frank, 1991, p. 70.) There are an infinite number of points which are equally preferrable to **B** and these form the indifference curve shown in figure 9. The consumer will be indifferent to any bundle that falls on this curve.

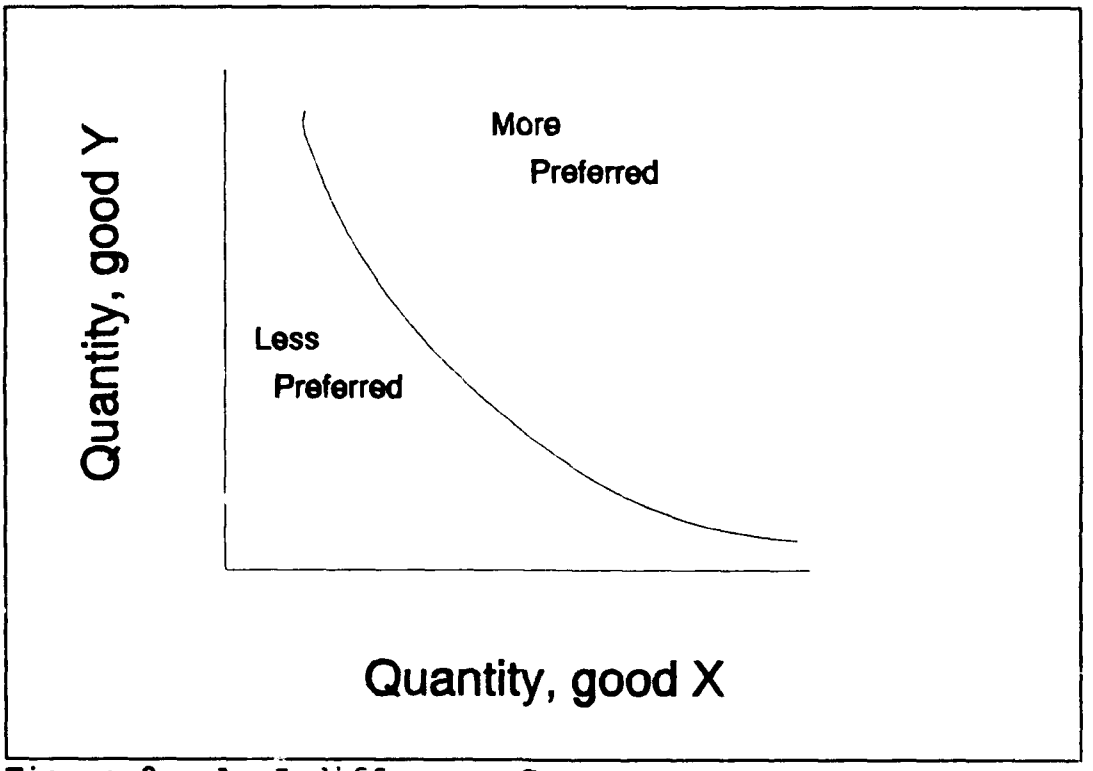

Figure 9. An Indifference Curve

The indifference curve allows us to compare bundles above and below the curve. Any bundle falling above the curve will be preferred to any bundle below the curve. The assumption that all possible bundles may be compared implies that there

is an indifference curve passing through every bundle. Indifference curves form an indifference map when graphed on the same set of axes.

Indifference curves can be viewed as a projection of the utility function, **U=U(X,Y)**. The *cardinal utility* approach assumes a specific value can be assigned to the utility function. Utility can then be maximized subject to the consumers budget constraint using lagrangian multipliers and calculus. Where there are only two goods, an easier method of finding the consumer's maximum utility is to solve the budget constraint for **Y** in terms of **X** and substitute the result into the utility function. This makes utility a function of **X** only. Then take the first derivative with respect to **X** and equate it to zero. This procedure maximizes the utility function resulting in the optimal value of **X**. This value is then substituted back into the budget constraint and solved for **Y**. Graphically, the maximum utility that can be achieved where the indifference curve is tangent to the consumers budget constraint, as shown in figure 10.

3. Marginal Utility

The marginal utility (**MU**) of a single product is defined as the change in utility a consumer experiences from the product as the consumer buys an additional unit. Marginal utility depends on the total number of units the consumer buys. All other factors are held constant. The change in

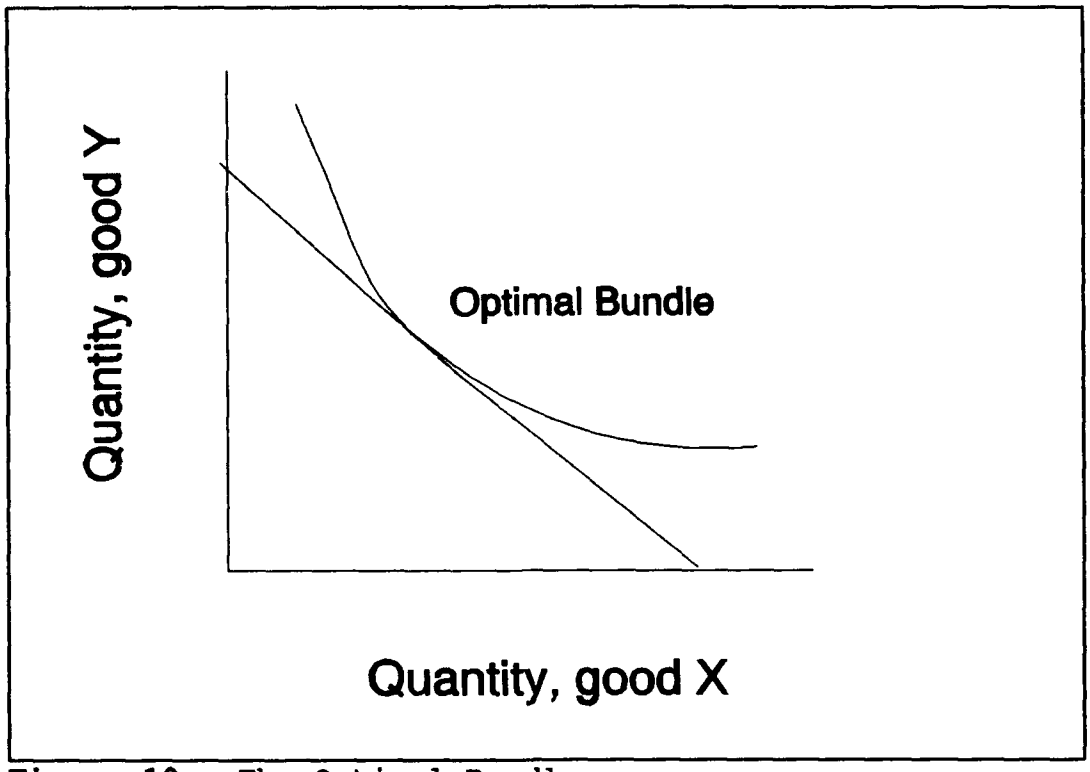

Figure 10. The Optimal Bundle

total utility is divided by the number of additional units the consumer purchases of the good. Because consumers tend to become satiated with most goods, marginal utitlity tends to decline as more units are purchased, giving rise to diminishing marginal utility, as shown in figure 11. Thus, total utility increases at a declining rate.

G. UTILITY AND THE DEMAND CURVE

Utility and budget are the underlying concepts of the demand curve. When something is known about a consumer's utility map (ie indifference curves) and budget available, a demand curve can be constructed. A consumer will maximize the

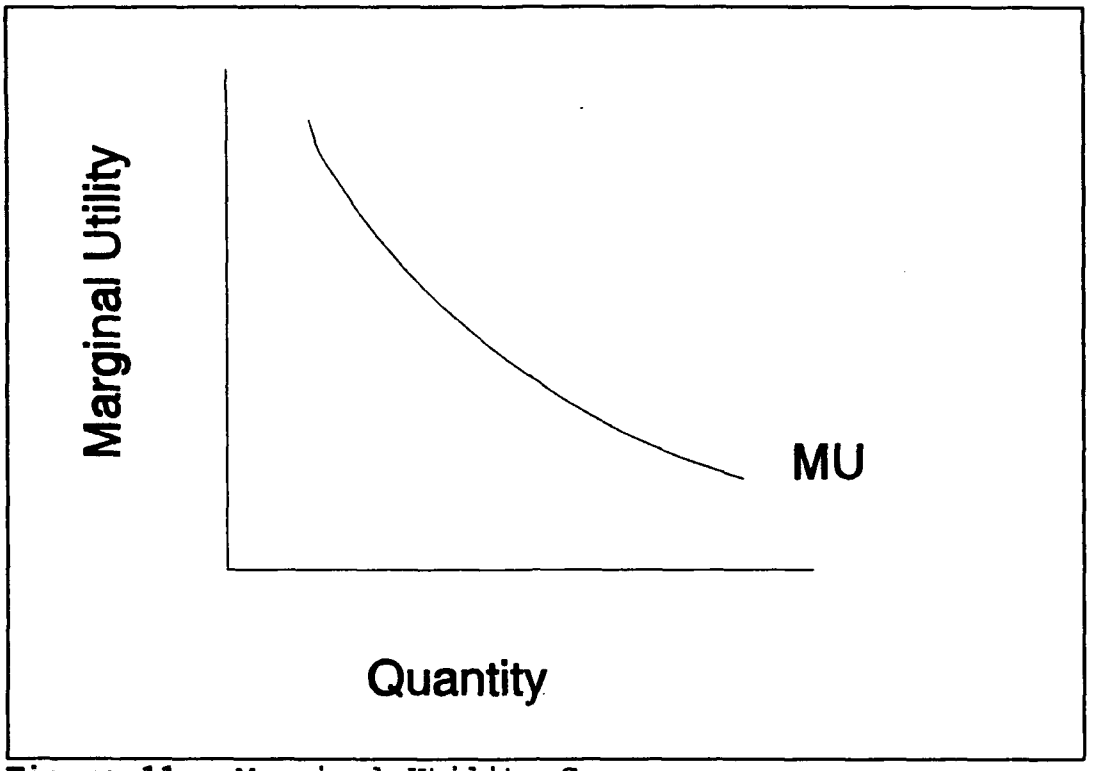

Figure 11. Marginal Utility Curve

amount of utility recieved from each available dollar. The equilibrium of the consumer is reached when the marginal utility of each item they buy divided by the item's price is equivalent to the marginal utility of every other good bought divided by their respective prices, or $MU_A/P_A=MU_B/P_B...=MU_N/P_N$ when N goods are available. Marginal utilities are divided by price to normalize accross items with different prices. The consumer exhausts their income through buying many different goods in the same manner. A demand for each good the consumer buys can be constructed for individual consumers of each product. To derive the demand curve, the price of one good is varied holding everything else constant. The demand curve

shows how the utility maximizing quantity of the good changes with the price of the good. Each consumer's demand is summed with all other consumers' demands in the same market to construct the market demand for individual products.

III. THE NAVAL TELECOMMUNICATIONS SYSTEM

A. GENERAL

1. Mission and Function

The mission of the Naval Telecommunications System (NTS) is to provide and maintain reliable, secure and rapid telecommunications, based on war requirements, to meet Naval command and control needs, ease Naval administration, and satisfy the Joint Chiefs of Staff approved requirements. (NWP4, 1977, p. 3-1) The navy has a world-wide network composed of assorted subnetworks that use various transmission medias to fulfill this mission. The method of transmission within the NTS is important because transmission rates help determine the quantity of message traffic supplied by NTS. The transmission method over the network does not impact the originator, except that the user must have access to the system.

Components of the NTS include networks, such as the Naval Communications Processing and Routing System (NAVCOMPARS), Fleet Broadcast, Local Digital Message Exchange (LDMX), and Common User Digital Information Exchange (CUDIXS)/Naval Modular Automated Communications System (NAVMACS). There are also voice and radio networks to allow verbal rather than record service.(Babb, 1987.) This analysis

will be directed exclusively to those systems which process record or "hard copy" message communications. These systems can be broken into two primary functions, communications ashore and fleet communications.

The term communications ashore will refer to any message using the NTS for the purpose of sending messages between commands that exist in on shore facilities. Fleet communications will refer to communications that are conducted between an operational unit and a shore unit, or between two operational units using the NTS. Operational units include ships, aircraft, submarine, and other tactical units using record communications to support operations.

2. Communications Ashore

The NTS subnetworks processing communications ashore include NAVCOMPARS, RIXT, and LDMX. These systems allow NTS to interface with the Defense Communications System (DCS). The DCS, through the Automatic Digital Network (AUTODIN), provides the primary trunks which link the NTS with Navy and other Department of Defense (DOD) subscribers. This comprises most of the internal network used by communications ashore.

3. Fleet Communications

Fleet communications are linked with the shore components of NTS through several networks. NAVCOMPARS provides message storage and delivery to fleet units and keys

the Fleet Satellite Broadcast (FSB). The FSB is the primary means of providing the fleet with record traffic and information. It is a one way, send only communication channel from shore to ship. The FSB serves all Navy surface units, designated Coast Guard ships and USMC radio communications shelters when required. Although communications have a complex physical configuration, the NTS and associated connectivity are theoretically quite simple, as shown in figure 12.

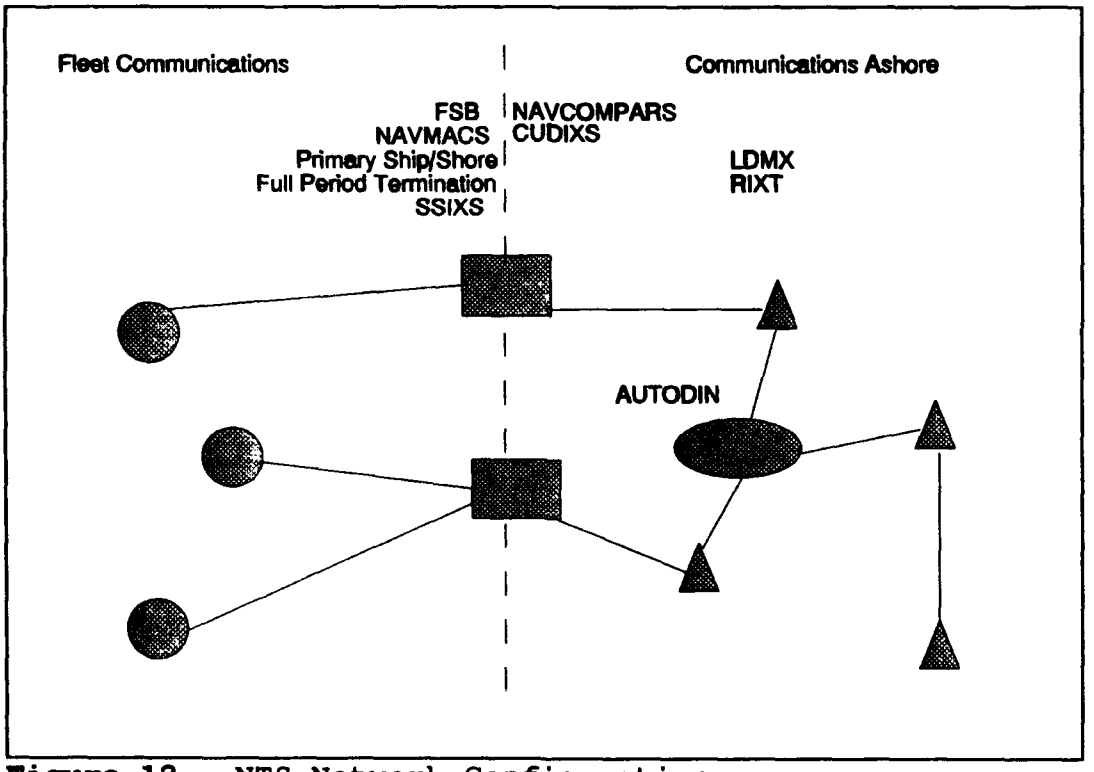

Figure 12. NTS Network Configuration

Exchanging traffic between surface and shore based commands is accomplished through CUDIXS/NAVMACS. The shore based CUDIXS portion of this subsystem receives ship-to-shore

message traffic. It is then routed to NAVCOMPARS. The NAVMACS element on board the ship provides send/receive or send only capabilities to the fleet, depending on the ship's communications configuration. The ships which send only on NAVMACS receive their traffic via the FSB. Pimary Ship/Shore and Full Period Terminations are also available for send and receive access to shore communications. Submarines send and receive their traffic through the Submarine Satellite Information Exchange Subsystem (SSIXS), or they may establish a full period termination when appropriate.

B. CHARACTERISTICS OF NAVAL MESSAGES

Characteristics of messages sent by NTS are unique in three areas; precedence, security, and administrative designation. Other characteristics, such as originating command, addressees, and text, are characteristics shared by all forms of record communications. If the unique characteristics can be met by other transmission services, then they can be considered substitute services and can replace some of the traffic currently submitted to the NTS for transmission.

The unique characteristics determine the order messages will be processed, the speed of service (SOS) objectives, the security requirements while processing, and the type of information that can be found in the message.

1. Precedence

The precedence of a message is the characteristic which is used for ensuring information arrives in a timely manner. The precedence system allows the user to indicate a requested SOS for their outgoing messages. These goals are measured from the time of delivery to the servicing telecommunications center(s) to the time of receipt by the addressee. The originating command indicates precedence. The telecommunications center(s) processes messages in order of precedence. The NTS is also programmed to give messages with a higher precedence priority within the system. The following precedence standards are in effect:

- Flash (Y/F): Process as fast as humanly possible. Goal: not more than 10 minutes.
- Operational Immediate (O): Thirty minutes from time of delivery to the system to time of receipt.
- Priority (P): Four hours from time of delivery to time of receipt.
- Routine (R): Eight hours from time of delivery to time of receipt.(NTP 3, 1987, p. 4-1)

2. Classification

Classification of a message determines the security accorded during message handling and transmission. A message must be handled by personnel with an equal or higher classification than the information contained in the message. Similarly, it must be transmitted over media encrypted at an

equal or higher classification level. The originating command determines classification based on the information contained in the message. Classification levels, from highest to lowest, transmitted by the NTS are:

- Top Secret (TS): Information which could cause grave damage to the security of the United States.
- Secret (S): Information which could cause serious damage to the security of the United States.
- Confidential (C): Information which could damage the security of the United States.
- Unclassified (U): Information which may be sensitive but does not cause damage to the security of the United States. (NTP 3, 1987, p. 7-1)

3. Administrative Designation

Administrative designation defines the type of information contained in a message and is divided into two large categories: administrative and operational. Administrative (ADMIN) messages are those which are administrative in nature and have to do with the everyday running of the Navy. ADMIN messages are never allowed to carry a precedence above priority, but may carry any classification level. Operational messages deal with operational activities. They may carry any precedence or classification level.

Precedence, classification, and administrative designation combine to determine the overall type of message being transmitted and the way it will be handled by the NTS.

All three characteristics are determined by the originating command and are not changed or questioned by the servicing telecommunications center personnel. Communications personnel simply verify the message format for transmission purposes.

C. THE DEMAND FOR THE NTS

Any individual authorized to draft, release and/or process electronically transmitted messages can use the NTS. A user will be defined as the command who has released the message for transmission because the originating command must designate personnel to submit messages under the command's authority.

Users' access to the NTS is limited by the speed they can originate and deliver messages to their servicing telecommunication center(s). The cost of using the system is based on the opportunity cost incurred typing and delivering the message to the servicing telecommunications center(s) for transmission. The NTS is funded by the Commander, US Naval Computer and Telecommunications Command (COMNAVCOTELCOM) and not the individual commands using the system. The lack of price incurred by the user causes the quantity demanded for the system to be unusually high. Commands will tend to use the system as long as they derive any positive return from sending traffic, or approximately where Q_d=P=0, as shown in figure 13.

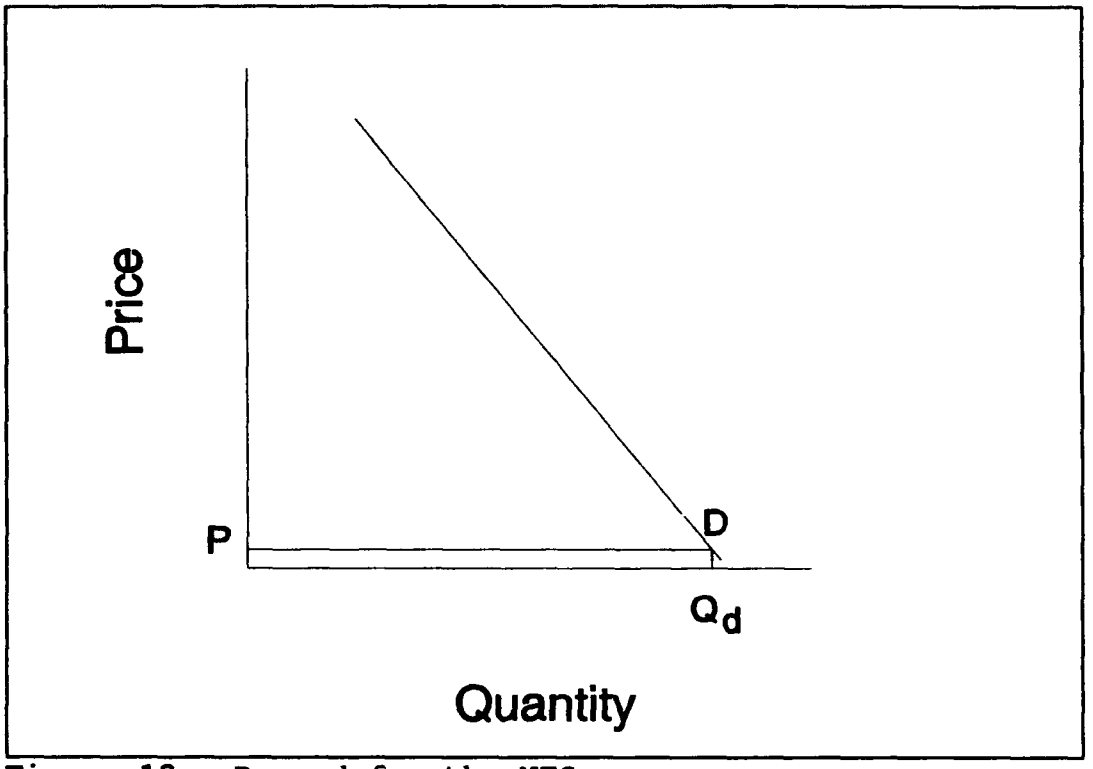

Figure 13. Demand for the NTS

The demand curve for telecommunications also experiences a fairly regular shift, depending on the time of day or week. Although demand by individual users depends on the needs of the user, most servicing telecommunications centers ashore experience an increase in demand (ie shift in the curve) to the right on Friday afternoons (local time) and a decreas in demand during Saturdays and Sundays. These periodic shifts seem to be attributable to the last minute business carried out by commands on Friday to prepare for weekends of relative inactivity. Commands in the fleet do not have the luxury of weekends, but tend to have higher demand during periods of increased operational tempo. These shifts cause a fluctuation

in Q_4 but do not promote a change in user behavior because the price of a message does not increase or decrease to compensate.

Price does not act as a regulating factor on the quantity of messages transmitted because the users' price is approximately zero reguardless of the amount of messages being transmitted. If prices do not respond to market changes, users will always prefer sending messages via the NTS over any other method available.

Y, TS, Operational	O, TS, Operational
Y, S, Operational	O, S, Operational
Y, C, Operational	O, C, Operational
Y, U, Operational	O, U, Operational
P, TS, Operational	P, TS, ADMIN
P, S, Operational	P, S, ADMIN
P, C, Operational	P, C, ADMIN
P, U, Operational	P, U, ADMIN
R, TS, Operational	R, TS, ADMIN
R, S, Operational	R, S, ADMIN
R, C, Operational	R, C, ADMIN
R, U, Operational	R, U, ADMIN

LEGEND:

Y=Flash	TS=Top Secret
O=Operational Immediate	S=Secret
P=Priority	C=Confidential
R=Routine	U=Unclassified

Figure 14. Combinations of Naval Message Characteristics

Combining the three characteristics above produces twenty-four possible types of messages which may be handled by the NTS, as shown in figure 14. Any record communications media

that can be properly used to handle and transmit any portion of these combinations can be used as a substitute for the NTS for that set of messages. When a substitute media is used for a message, fewer messages will be sent via the NTS thereby reducing the demand on the system. Substitutes will be discussed further in chapter IV.

D. THE SUPPLY OF THE NTS

Allowing Q_d to expand to the point where the MV (or price) equals zero for the NTS would be acceptable if there was an unlimitted supply of record communications capability or the quantity of record communications supplied exceeded this Q_d. However, the quantity supplied, Q_s, of record communications supported by the NTS is a fixed quantity equal to the capability of the system. Supply is graphically depicted in figure 15 as a vertical line. The limitted quantity cannot be changed immediately and is costly to increase over the long run. The Navy would have to increase the data rate of existing transmission media and/or introduce new systems/circuits. Finding an optimal supply for the NTS involves detailed analysis of data that is not currently available for the system. The produces a condition of excess demand in which the NTS cannot supply messages which meet SOS requirements.

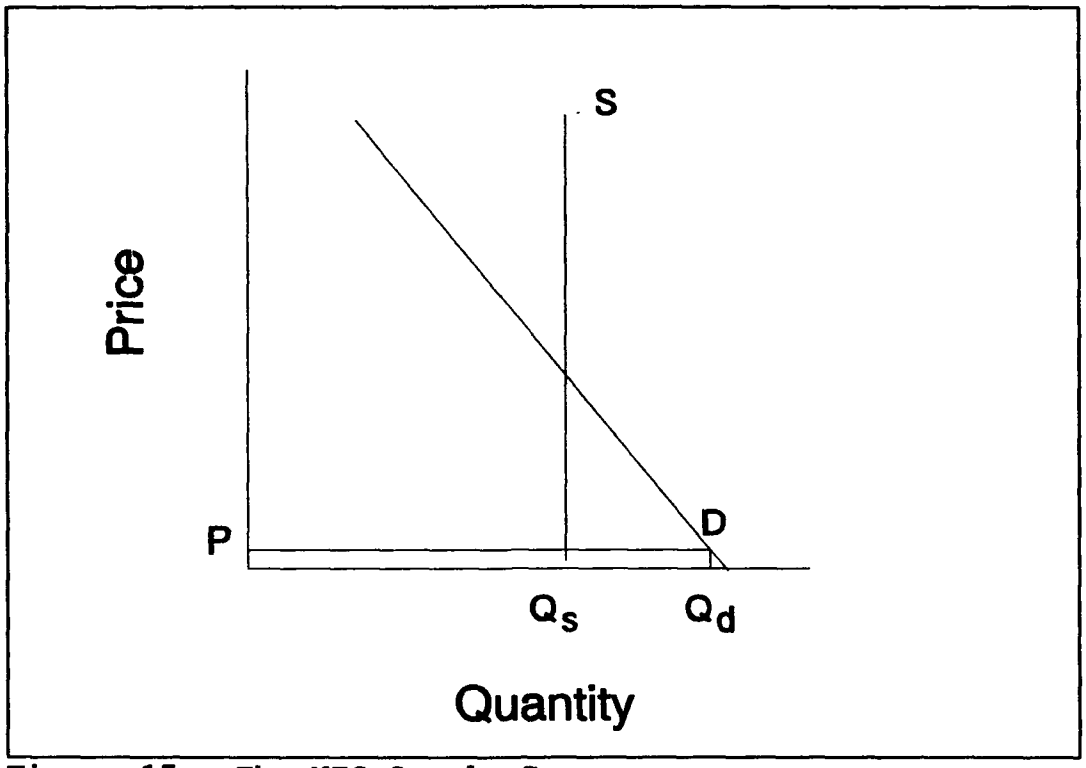

Figure 15. The NTS Supply Curve

E. EFFORTS TO MANAGE EXCESS DEMAND

The limitted supply available to NTS users and time related shifts in demand regularly create shortages and surpluses. The Navy can pursue two basic methods to combat these fluctuations; controlling supply and/or controlling demand more efficiently. The function of ensuring efficiency in a competitive market is price, but pricing the services offered by the NTS would be hard to implement in the military environment. (DiMaggio, 1989)

Increasing supply may eventually end the occurances of excess demand, but would leave the system with frequent surplus in availability. An undesireabile effect of

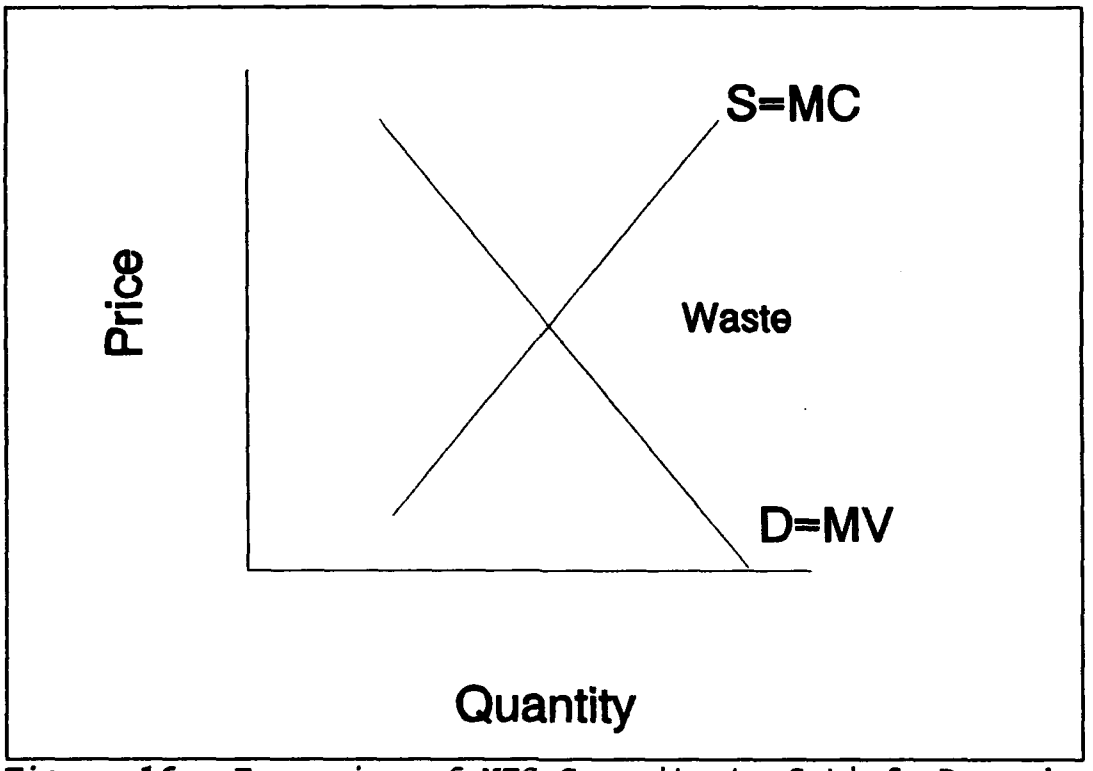

Figure 16. Expansion of NTS Capacity to Satisfy Demand

increasing supply may be the reaction of users to take even more advantage of the "free" record communication services of NTS. The current delays are opportunity costs to the user. These are one of the few costs limiting demand and would no longer be a consideration with increased supply. The users would still use the system at Q_d=P=0 and move along the demand curve to gain maximum benefit. Additionally, expanding supply to satisfy all demand would not be efficient use of the Navy's resources. This type of expansion would continue beyond the equilibrium point and MC would be greater than MV, as shown in figure 16 .

Demand management has been pursued administratively by the Navy through instructions and directives. Administrative policies to control message volume have achieved a degree of success. (DiMaggio, 1989, p. 17) However, there exists a condition of excess demand and demand continues to fluctuate drastically with changing world situatuions.

IV. THE NAVY MARKET FOR RECORD COMMUNICATIONS

A. GENERAL

The NTS is one portion of the total market for record communications in the Navy. Any means of sending record communications that satisfies the characteristics of naval messages can substitute for the NTS and part of the larger market for record communications. Possible substitutes for the NTS are facsimile, personal computer (PC) networking, and the United States (US) Postal Service. Increasing the use of substitutes will reduce demand for the NTS system.

B. SUBSTITUTES FOR THE NTS

1. Facsimile (FAX)

Facsimile machines are widespread in the civilian business community and, to a lesser extent, the military. FAX machines must be purchased by individual commands and use a dedicated telephone line. With the recent acquisition of the third generation Secure Telephone Unit (STU III), the Navy has the capability of sending classified information via FAX for the price of a telephone call. Any type of message may be transmitted by FAX provided the user and receiver have STU III encryption levels coinciding with the classification level of the information being sent. The advantage of FAX transmission is the virtually instantaneous receipt of the message. The

primary disadvantage is the requirement for personnel to be present at the receiving command to ensure proper handling of any classified message traffic. FAX may be used to transmit to multiple addressees if a PC is connected which has the appropriate software. Classified messages may be sent by FAX if there is prior coordination to ensure personnel with the proper security clearances are present to receive the message. Prior coordination for multiple addressees of classified traffic requires extra time and manpower. Many unclassified messages are considered sensitive and should have personnel at the receiving end to ensure no unauthorized or unneccessary access. Therefore, the price of sending a multiple adressee message is considerably higher than for sending a message to a single adressee.

FAX transmission is unavailable for fleet communications, but may be made available for communications ashore. There are 20 types of messages FAX transmissions could replace ashore, including all operational immediate, priority, and routine. Flash messages would require telephone coordination which may prohibit FAX from meeting SOS goals. Therefore, FAX is not considered replacement for Flash messages. FAX machines set up in the Duty Offices of users would ensure 24 hour accessibility.

2. Personal Computer Networking (PC)

The Personal Computer (PC) has become commonplace in the Navy. Unfortunately computer modulator/demodulators (MODEMs) have not been included in the GENERAL purchase of PCs. The purchase of MODEMs and the appropriate software, combined with STU IIIs, would allow record communication transmission generally equivalent to the NTS. Messages of all classification and administrative designation could be sent to multiple addressees simultaneously. Computer software could easily be designed to alert the destination when high precedence messages were being received and receipt files in the computer would alleviate the necessity for the receiving command to have personnel present during transmission. Access to PC networks would require the using commands to purchase a MODEM, software, a dedicated telephone line, and a STU III hooked up to the system. The network user would pay for a telephone call. The price of using the network, assuming comprehensive access, would be slightly less than FAX due to the reduced personnel involved and ability to transmit to multiple adressees.

PC network communication is a perfect substitute for all types of communications ashore but unavailable to fleet communications. Setting up the network to transfer receipt to a command duty office for screening during non working hours

would ensure 24 hour accessability. During working hours, the messages could be received at the desk of the intended reader rather than a centralized command location.

3. US Postal Service

The US Postal Service can be considered part of the market for record communications. The record communications currently being sent by NAVGRAM in naval message format are a consequence of administrative policy and have already reduced demand for the NTS. According to these administrative policies, commands should be using the US Postal Service to their best advantage already. There is little hope for administrative policies to change NTS demand by further increasing the use of the US Postal Service. In the future, if commands plan their administrative record communications more in advance, use of the US Postal Service may help reduce the demand for the NTS. However, the remainder of the thesis will exclude this possibility.

C. MARGINAL UTILITY OF RECORD COMMUNICATIONS

Marginal utility and price are directly related to demand. Individuals maximize utility by buying goods where the **MU/P** is equal for each available good. Users of record communications maximize their utility when $MU_{NTS}/P_{NTS}=MU_{FAX}/P_{FAX}=MU_{PC}/P_{PC}$.

The price of NTS service is minimal for users because they do not bear the costs of operating the system. At the same time, users bear most of the costs of FAX and PC networking.

If the price of the NTS is artificailly low, users will increase their use of the NTS to equate the MU/P for NTS, FAX and PC networking. In particular, as use of the NTS expands relative to FAX and PC networking, MU_{NTS} will fall, due to diminishing marginal utility. At the same time, MU_{FAX} and MU_{PC} will increase. This adjustment process will equate $MU_{NTS}/P_{NTS}=MU_{FAX}/P_{FAX}=MU_{PC}/P_{PC}$ when P_{NTS} is artificially low. This causes the NTS to be overused. If the price of using the NTS were to increase, MU_{NTS}/P_{NTS} would decrease. To equate MU/P, users would reduce their demand for NTS and begin to transmit more messages using FAX and PC networking.

Because FAX and PC networks are unavailable to fleet communications and there are no other substitutes for Naval messages, fleet communications users' utility maximization will rely entirely on the NTS. The low price of the NTS motivates fleet communications users to expand their use of the NTS until the marginal value of the last message equals the user's cost of sending the message. Because the substitutes for the NTS are limitted for fleet users, the MV_{NTS} reflects the MV of that message.

NTS, FAX and PC networking are relatively close substitutes for ashore users. As with fleet users, the low price of NTS will encourage ashore users to expand their use until the marginal value of the last message sent on the NTS equals the user's cost of sending the message. However, in this case, the MV of NTS reflects the increase in value of

sending the message via the NTS as opposed to sending the message via FAX or PC network. Thus, it is likely that the demand for the NTS by ashore users would be more responsive to the price of the NTS than the demand by fleet users.

If the DON raised the price of the NTS in order to reduce demand, both fleet and ashore users would reduce the number of messages sent via the NTS. At the new price, the MV_{NTS} would be equal to P_{NTS} for both users. However, it is likely that ashore users would reduce their demand for the NTS more than fleet users because they have closer substitutes for the NTS. Unfortunately, it is impossible to determine the optimal mix of use to cut from each community without prices. If demand for the NTS needs to be reduced, it is more prudent to concentrate on communications ashore users because there are other forms of record communications available ashore.

Efficient use of the NTS would provide the maximum value to all users. When there is excess demand for a good, the lowest valued user should be denied the good in favor of higher valued users. Because we cannot determine the point at which fleet communications may have a lower value than communications ashore, and we know the fleet has no substitutes for the NTS, we should attempt to give priority to the fleets' demand for NTS services over the needs of communications ashore. The current NTS system does not differentiate between fleet communications and communications

ashore when accepting messages for transmission. Therefore this system is likely to be inefficient in distributing assets.

D. THE DEMAND FOR RECORD COMMUNICATIONS

Current access to FAX and PC networks is limitted because of budgeting restrictions for communications ashore transmission. Therefore, the users ashore may have only the NTS, or the NTS and one other option, available for transmitting record communications. Users do not expend any of their budget for NTS use. However, they must use some of their budget to gain acces and use FAX and/or PC networks. Thus, they will send messages via the NTS and not utilize FAX and/or PC networks.

The question facing user commands and the Department of the Navy (DON) is how to find the optimal mix of record communications to maximize efficiency.

E. THE MARGINAL COST OF RECORD COMMUNICATIONS

1. Marginal Cost to the User

The marginal cost of the NTS (MC_{NTS}) is the same for fleet communication or communications ashore users. MC_{NTS} is essentially horizontal and becomes vertical when system capacity is reached. MC_{FAX} and MC_{PC} are always upward sloping, showing the costs of telephone lines and higher operation costs to the user. MC_{FAX} is higher than MC_{PC} because FAX has

higher opportunity costs in the form of coordination. FAX and PC are not available to fleet communications users. Thus, they are irrelevant for those users. However, MC_{FAX} and MC_{PC} are important for communication ashore users.

Assuming total access by all possible users of communications ashore, commands will continue to demand higher levels of the NTS due to negligible price. The marginal cost of each form of record communications that are substitutable for the NTS (MC_{NTS}, MC_{FAX}, MC_{PC}) are horizontally summed to form the total MC of communications ashore, MC_{COMM}. Users will continue to use the NTS until they receive a marginal benefit equal to MC_{NTS}, which is negligeable. Users will not begin to use FAX or PC networking until their marginal cost falls below the marginal cost of the NTS or the NTS system has reached capacity, as shown in figure 17.

2. **Marginal Cost to the Department of the Navy (DON)**

The DON experiences a different marginal cost for record communications because all record communications carry a price to DON. The DON is ultimately the supplier of all record communications. The NTS has positive operating costs to DON before system capacity is reached. DON also has the option of increasing system capacity by one more unit in the long run. Increasing system capacity is reflected by a vertical break in MC_{NTS} at the current capacity. MC_{NTS} then continues to slope upward until the next increase in system

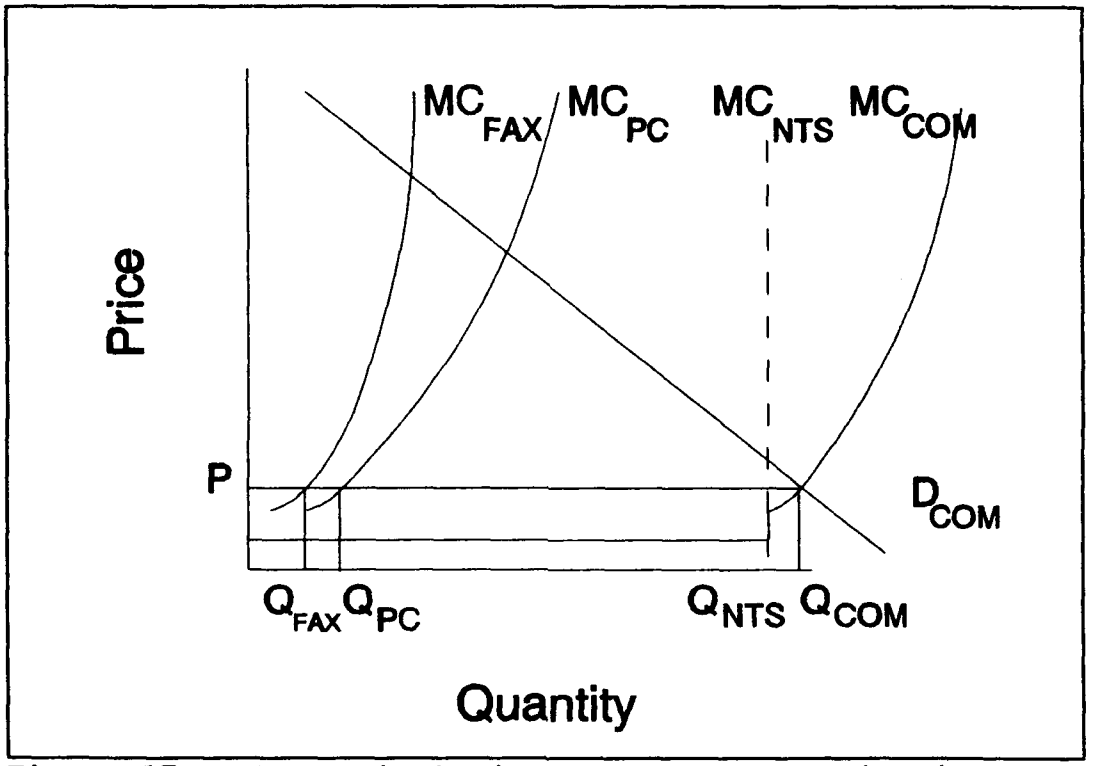

Figure 17. The Optimal Mix of Record Communications for the User

capacity is required. Considering this, it is evident that DON and the fleet ashore users face different MC_{NTS}.

The DON has a broader view of the record communications market and therefore is in a better position to find the most economically efficient combination of record communications to supply for the navy. Finding the best mix of record communications is done by superimposing the demand for record communications over the marginal cost curves for all forms of record communications. The point that maximizes the systems' net value occurs where $D=MC_{COM}$. Q^* and P^* are read from the axes. They are the optimum amount of record communications to supply and the optimum price (or marginal

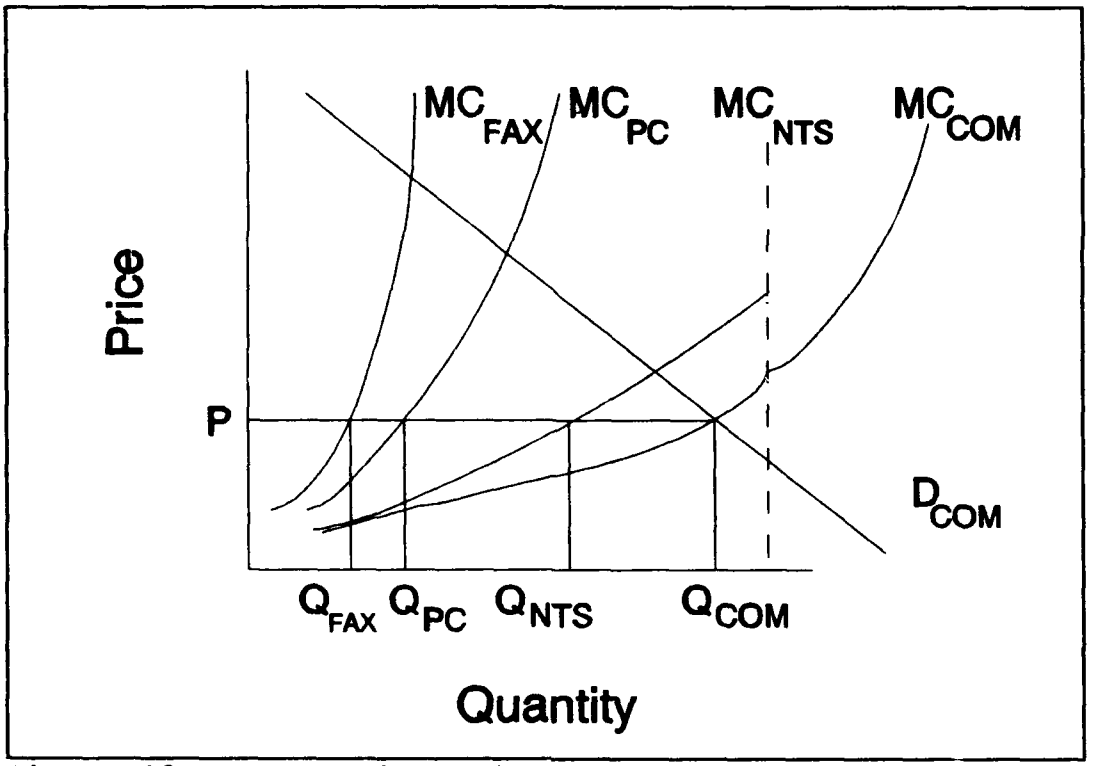

Figure 18. The Optimum Mix of Record Communications for DON

value of the last message to the user). Dividing Q^* into the proper amounts of each type of record communications is achieved by allowing P^* to equal the respective MC curves as shown in figure 18.

Because DON and the using commands face different MC curves, in particular for MC_{NTS}, the optimal mix of record communications are not equivalent for the DON and the users. Specifically, the users will demand too much NTS service because they face an artificially low MC_{NTS}. The DON must find methods to motivate users in a way which will produce an optimal mix of record communications. The DON is in the situation of being a producer with multiple products.

V. REDUCTION OF THE NTS DEMAND

A. GENERAL

The DON, as the supplier of record communications, should try to maximize the utility of the entire market for Navy record communications. The intent is to get users' MC curves to reflect those of the DON. Options to DON include imposing a price on the NTS, introducing inefficiencies which make the NTS more difficult to use, subsidizing all record communications, and/or administratively denying use of the NTS to low benefit users.

B. PRICING THE NTS

Imposing a price on the NTS would promote users to behave in a way similar to the DON. The pricing scheme would have to take into effect peak loads and priority requirements to be most effective (Dimaggio, 1989). Peak load pricing imposes a surchage for messages transmitted during times of increased demand. Priority pricing imposes a graduated scale surcharge depending on message priority.

Pricing naval messages has many disadvantages and requires policy decisions on how pricing would be implemented. An extensive accounting system would have to be developed and funding be directed from COMNAVCOTELCOM to user commands for payment. Questions include: Would the sending or receiving

command pay for NTS service?; Would the messages be priced by length or number of addressees?; Would a command that ran out of funding for message traffic during a specific period be excluded from NTS service?; and, If a command required information in message format, would they be charged? In addition to the extensive policy decisions required to price naval messages, there would be a great amount of resistence from the Navy community which is accustomed to using the NTS as a "free" service.

C. INEFFICIENCIES

Inefficiencies could be introduced into the NTS by increasing the opportunity costs of transmitting naval messages. Current opportunity costs include the time to produce and deliver a message, the value of the equipment equipment used in typing a message, the time required to obtain authorizations to access the NTS (i.e., releasing authorization and messenger authorization), and the SOS delays experienced from excess demand. These costs are minimal and almost identical to similar costs of other transmission methods. Additional inefficiencies may be introduced by requiring a more complicated format for general service massages or by making access to the NTS more difficult.

Introducing inefficiencies to a system which is not currently efficient makes the system less able to service the

using commands. Increasing the inefficiencies could entirely defeat the purpose of naval telecommunications or reduce the Navy's ability to command and control its forces.

D. SUBSIDIZING ALL NAVAL RECORD COMMUNICATIONS

The DON could transfer the funding of all naval record communications to COMNAVCOTELCOM, thereby causing the users' MC_{FAX} and MC_{PC} to seem similar or identical (depending on the amount of the subsidy) to MC_{NTS}. The DON would still experience the same MC curves as before, but may be able to reduce D_{NTS} if some users switched to other forms of record communications as their prices fall relative to the NTS. D_{NTS} would fall if Q_{NTS} were below the capacity of the NTS. Subsidizing FAX and PC networks would lower their MC curves. When MC_{FAX} and MC_{PC} were horizontally summed with MC_{NTS}, MC_{COM} would rise and increase Q_{FAX} and Q_{PC} while decreasing Q_{NTS}.

Excess demand currently experienced by the NTS implies that Q_{NTS} is greater than the NTS capacity. Subsidizing FAX and PC networks may have two different results depending on the location of D_{COM}. If D_{COM} falls on a vertical segment of MC_{COM}, subsidies may lower or raise Q_{NTS}. If users preferred FAX or PC networks to the NTS, Q_{NTS} may be reduced. Alternatively, users may prefer NTS services over FAX or PC networks. In this case, Q_{NTS} would remain the same or increase slightly.

The huge disadvantage of subsidization would be the possibility of Q_d increasing with comparable increases in Q_{FAX} and Q_{PC}. This could occur if D_{COM} is above a vertical rise of MC_{COM} at NTS capacity. Subsidizing FAX and PC networking would increase the use of all record communications. MC_{COM} would remain very low and the rise would be less sharp when subsidized MC curves for FAX and PC networks were horizontally summed with MC_{NTS}. The resulting MC_{COM} would cross D_{COM} further along the horizontal axis at a lower P. The only control for using record communications would be the supply given to each command and a constant request for increased supply could occur.

E. ADMINISTRATIVE DENIAL

1. General

Denying access to shore communications users during specific periods or for specific types of messages would shift Q_s for those users to the left, forcing those commands to consider alternative means of shore communications. Administrative denial may be implemented several ways: denial by precedence, denial by community, and denial by time period.

2. Denial by Precedence

Denial by precedence implies that certain precedences would not be transmitted via the NTS. The most feasible execution of this would be denying use of the NTS for routine administrative messages sent between shore commands within the

United States. These messages have the lowest SOS requirements and may be transmitted by FAX or PC networks. The US Postal Service can deliver these messages in the form of NAVGRAMS normally within three to five working days.

Implementation would require giving authority to servicing telecommunications centers to not transmit messages which fell within these guidelines. Many users might object to giving telecommunications personnel such authority, but if directives were established at appropriate levels, users would have to adhere to these directives. Another consideration prior to beginning this type of program is that users decide precedence and indicate administrative designation. If users control these portions of a message, they may artificially inflate the precedence or indicate administrative designation incorrectly, thus circumventing the denial process.

3. **Denial by Community**

All communications ashore could be denied access and required to use other methods of record communications. Any communications between the fleet and a shore command may be transmitted via the NTS but, in the case of multiple addressees, the addressees which are other shore commands would have to be sent by other means (ie the operating signal ZEN would be placed in front of the address on the message). Address Indicating Group/Collective Address Designators (AIG/CADs) would have to be screened for each message sent

from a shore command. All addresses within the AIG/CAD would have to be sent by other means.

Denial by community would cripple many of the record communications currently conducted through the NTS. All users would need access to other forms of record communications and a surplus of communications capabilities might exist in shore servicing telecommunications centers. Personnel and equipment would still be required to transmit high precedence communications to the fleet. In order to ensure that SOS requirements are met for communications to the fleet, only small reductions in personnel and equipment are likely. Thus, the reduction of personnel and equipment wouldn't be comparable to the reduction in messages transmitted at shore servicing telecommunications centers. The average cost for supplying NTS communications at these centers would rise significantly. More importantly, with surplus personnel and equipment at many times, the MC of sending an additional message on the NTS would be close to zero. Efficiency requires that demand for the NTS be reduced, but not too drastically.

4. Denial by Time Period

Denying transmission of low priority traffic is currently accomplished by imposing minimize for regions of operational activity. Minimize may be imposed by the Joint Cheifs of Staff or a Flag Commander within his region of

authority. Minimize requires the originating command to type "MINIMIZE CONSIDERED" at the end of a message being sent to or from a command under minimize. Minimize is marginally effective because the users' cost of sending messages to that area is nineteen keystrokes of a typewriter or word processor. Some users are very consious of minimize and use it properly. The imposition of minimize during Desert Shield and Desert Storm did not alleviate extreme demand on the NTS. Many of the messages received in the Gulf Theatre were Operational Immediate and higher precedence. The routine and priority message traffic was not even reviewed by action officers and, in some cases, communications personnel routed one copy of priority and below to an officer whose only duty was reviewing this traffic to determine if the command really needed it.

An alternitive to minimize is actually denying transmission of any traffic between shore commands that is not directly related to the current crisis. This may alleviate demand for the NTS within the United States. The reduced demand within the United States may allow messages transmitted to the crisis area to reach the systems supplying the fleet faster and assist meeting SOS goals at fleet units. If encugh demand were reduced ashore, the FSB and NAVCOMPARS system may have a backlog of messages. Determination of this condition could only be accomplished through detailed network analysis of the NTS and is beyond the scope of this thesis.

Denying access by time period may also be accomplished by relaxing the SOS objectives during peak time periods. Lower precedence messages delivered to servicing telecommunications centers during their peak periods could be marked "peakload traffic" and be allowed to be held before transmission until an period of relative inactivity. Because telecommunications personnel handle traffic in precedence order, they could ensure delivery of flash and operational immediate messages. Other precedence traffic could be held in order of priority and time of delivery to the center then transmitted when posible. Using commands would be informed of the exact policy and could take that into consideration when sending messages. The delay would become an additional opportunity cost to the user and give the telecommunications personnel some control to use the NTS with lower excess demand and less surplus capacity. The user could still indicate a higher priority to get his message transmitted, but a routine or priority message sent between shore stations on Friday is not likely to be acted upon until Monday morning anyway. Demand should be sufficiently low over the weekend to ensure that these lower priority messages are available to the receiver by Monday.

VI. CONCLUSIONS

A. GENERAL

This thesis has analyzed naval record communications using microeconomic theory. Excess demand for NTS has been measured by SOS objectives which are not currently met by the NTS. Excess demand implies an inefficient allocation of NTS resources. Improving efficiency may be accomplished by increasing supply or decreasing demand. Basic microeconomic principles of price, utility, and marginal analysis help explain excess demand for NTS services.

NTS users tend to view the NTS as an individual market. These users minimize their costs for record communications by using the NTS. The DON pays for all record communications and experiences different costs. When the NTS is viewed as a portion of the market for Navy record communications, as encountered by the DON, substitutes for some types of naval messages are found. Fleet communications are less likely to have access to substitutes. Therefore, communications ashore users are more likely to be able to reduce their demand for the NTS.

Record communications considered reasonable substitutes for the NTS are FAX and PC networking. Marginal cost curves for users and the DON have been constructed. The DON may

minimize cost and improve the efficiency of the NTS by using less NTS and more FAX and PC networking. Motivating users to reduce NTS demand may be accomplish through imposing a price on NTS services, introducing inefficiencies to the NTS, subsidizing all Navy record communications, and/or administratively denying access to the NTS.

B. RECOMMENDATIONS

Reducing demand for record communications in the Navy is a complicated process. If done inappropriately, it may be detrimental to the functioning of the service. However, finding an optimum mix of record communication services to reduce the demand of the NTS may be more readily accomplished through administrative policies. There are alternatives to administrative policies, including: prices, introducing inefficiencies into the NTS, and subsidizing FAX and PC networking. Imposing a price on the NTS is difficult administratively. Introducing inefficiencies to an inefficient system reduces the NTS servicing ability and reduces the value of communication services. If inefficiencies were imposed selectively, users transferring between fleet and shore commands would have to accomodate selective inefficiencies and some confusion about the transmission requirements would result. Subsidizing all record communications is not feasible during periods of limitted funding. The purchase of equipment to access FAX and

PC networks will be costly and can only be accomplished over a long period of time. Allowing users free communications may actually increase the quantity demanded for record communications and exacerbate demand excesses.

Administrative denial methods could be combined to reduce demand for the NTS during peak periods. The minimize system is marginally effective because there is no control over users when transmitting messages. Forced denial of access determined by precedence, community, and time period may be the most efficient and least costly form of control for NTS demand. Specific denial policies would have to be determined and promulgated by record communications managers. Supplying access to communications forms other than the NTS may be accomplished over a long time period and demand on the NTS reduced further without complete subsidization.

C. SUGGESTIONS FOR FURTHER RESEARCH

This thesis provides a framework for analyzing the record communications market for the Navy. The largest area available for further study is in areas of data collection and analysis. Several types of analysis are needed to find the optimal mix of record communications. Among these are:

- Data collection of the cost of all record communications followed by a market and cost analysis.
- Data collection and analysis of the NTS network and formulation of an accurate demand curve for the NTS.

- Data collection to determine the optimal mix of record communications including the types of messages and cost of substitutes.
- Data collection to determine the price of the NTS, taking into account all costs to the DON.
- Data collection and analysis of the extent of excess demand on the NTS and the amount of substitution which would reduce NTS demand enough to prevent excesses.
- Analysis of administraive policies suggested in this thesis and the cost of implementing them.

This data is currently unavailable in a central location and could provide a means for managers of record communications systems to make sound economic decisions when purchasing new systems, upgrading or adding capacity to existing systems, and deciding how to distribute budgets for record communications.

REFERENCES

Babb, Robin M., *The Naval Telecommunications System: A Command and Staff Manual*, Master's Thesis, Naval Postgraduate School, Monterey, California, March 1987.

De Leeuw, Jeffrey J., *Ideal System Capacity and Demand Management for the Naval Telecommunications System: An Economic Approach*, Master's Thesis, Naval Postgraduate School, Monterey, California, March 1990.

DiMaggio, Kathryn A., *Pricing as a Demand Management Tool for Record Communications*, Master's Thesis, Naval Postgraduate School, Monterey, California, March 1989.

Frank, Robert H., *Microeconomics and Behavior*, McGraw-Hill, Inc., 1991.

Heyne, Paul, *Microeconomics*, Science Research Associates, Inc., 1988.

Telecommunications Users Manual, Naval Telecommunications Procedure, Volume 3(G), February 1987.

SELECTED BIBLIOGRAPHY

Bailey, Rosalind T., *Proposed Model For Forecasting Demand For Telecommunications Services For the United States Navy*, Master's Thesis, Naval Postgraduate School, Monterey, California, March 1986.

Bronfenbrenner, Martin, et.al., *Microeconomics*, 3rd ed., Houghton Mifflin Co., 1990.

Dixit, A.K., *Optimization in Economic Theory*, Oxford University Press, 1976.

Hiltz, Starr Roxanne, and Turoff, Daniel, *The Network Nation: Human Communications Via Computer*, Addison-Wesley Publishing Co., Inc., 1978.

Maurice, S. Charles, and Smithson, Charles W., *Managerial Economics: Application of Microeconomics for Decision Making*, 3rd. ed., Irwin, 1988.

Menger, Carl, *Principles of Economics*, New York University Press, 1976.

Orr, George E., *Combat Operations C^3I: Fundamentals and Interactions*, Air University Press Maxwell Air Force Base, Alabama, 1983.

Ricci, Fred J., and Schutzer, Daniel, *U.S. Military Communications: A C^3I Force Multiplier*, Computer Science Press, 1987.

Truett, Lila J., Truett, Dale B, *Intermediate Microeconomics*, West Publishing Co., 1984.

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